

60639 Basalt identity crisis: origin from Apollo 11, 12 or elsewhere?

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Previous Work- 60639

- Rake sample
- Polymict fragmental breccia
- Various lithic clasts (Ryder and Norman, 1980):
 - Impact Melt Breccias (poikilitic, aphanitic, & glassy)
 - Anorthosite
 - Mare Basalt
 - Luna 16-type Basalt (Dowty et al., 1974; Delano, 1975)
 - Apollo 11 and 17 high-Ti Basalt (Murali et al., 1976; Ma et al., 1976)

Delano (1975) *6th Proc. Lunar Sci. Conf.*, 15-47.

Ma et al. (1976) *7th Proc. Lunar Sci. Conf.*, 37-47.

Ryder and Norman (1980) *NASA Cur. Branch Pub.*, 52, JSC 16904.

Dowty et al. (1974) *5th Proc. Lunar Sci. Conf.*, 431-445.

Murali et al. (1976) *7th LPSC*, 583-584.



Objective

- Characterize basalt clasts
 - Newly discovered clasts (January 2010)
 - Re-examine previously studied (Delano et al., 1975; Dowty et al., 1974; Murali et al., 1976; Ma et al., 1976)
 - Modern methods: bulk composition, mineral analyses
 - Whole-Rock
 - Major Elements: solution mode-inductively coupled plasma-optical emission spectrometry (ICP-OES) @ CEST, Notre Dame
 - Trace Elements: solution mode-ICP-mass spectrometry (ICP-MS) @ MITERAC, Notre Dame
 - Mineral Phases
 - Major Elements: Electron microprobe (EMP) @ Washington University in St. Louis
 - Trace Elements: laser ablation ICP-MS @ MITERAC, Notre Dame
- Few Additional Apollo 16 basalt Studies
(Hughes et al., 1988; Simon et al., 1987; Zeigler et al., 2006)

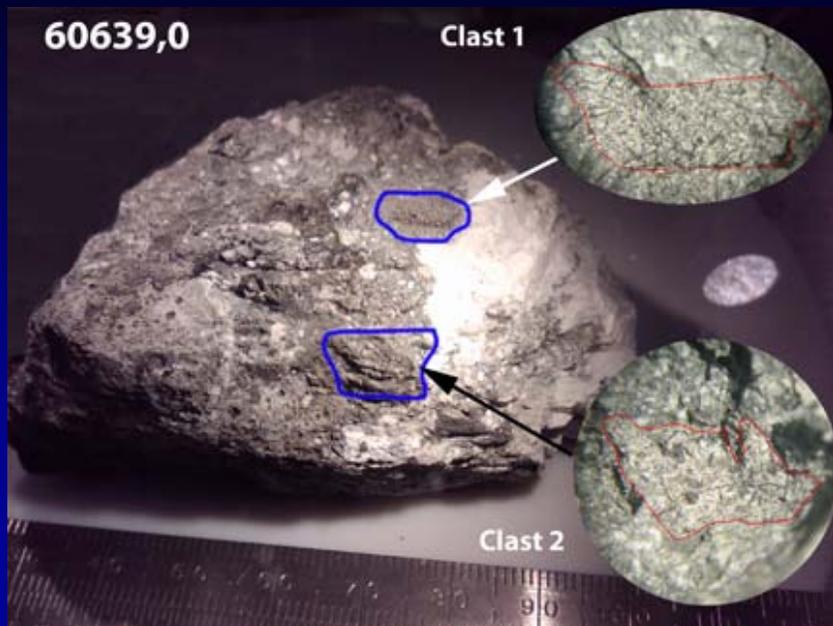
Delano (1975) *6th Proc. Lunar Sci. Conf.*, 15-47.

Ma et al. (1976) *7th Proc. Lunar Sci. Conf.*, 37-47.

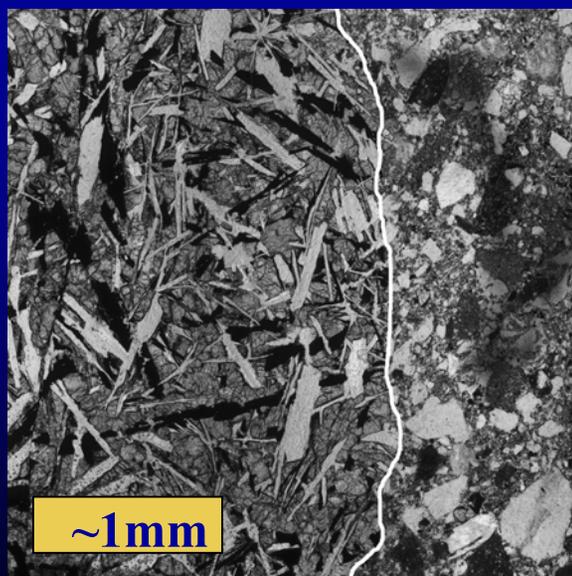
Dowty et al. (1974) *5th Proc. Lunar Sci. Conf.*, 431-445.

Murali et al. (1976) *7th LPSC*, 583-584.

“Mugshots”



- Coarse-grained
- Porphyritic
- Subophitic
- Feldspathic
- Basalt + Breccia



60639,2

Mineral Phases

- Plagioclase (35%)
- Pyroxene (50%)
- Olivine (5-10%)
- Ilmenite (5-10%)

Delano (1975)

- Cristobalite
- Fe-Ni Metal

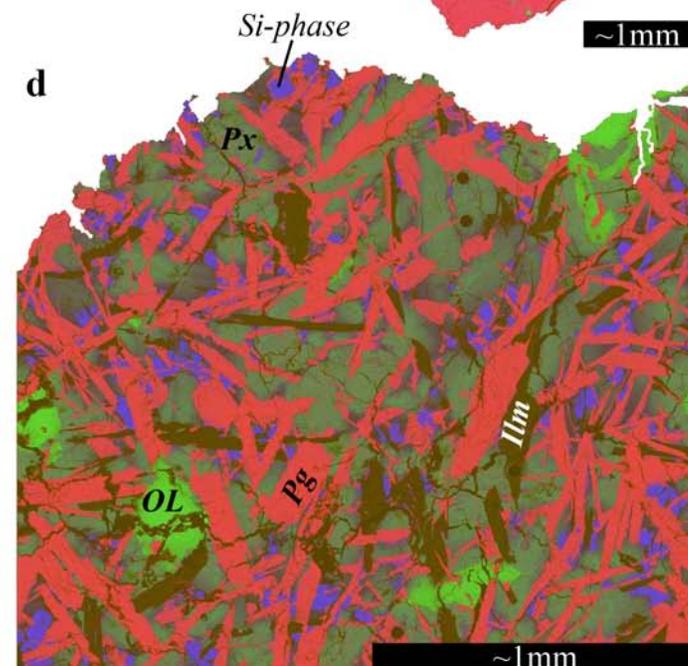
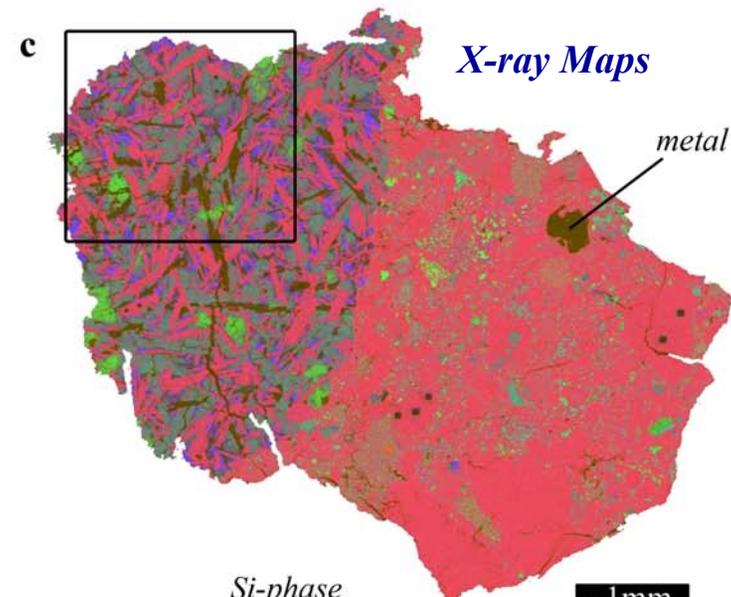
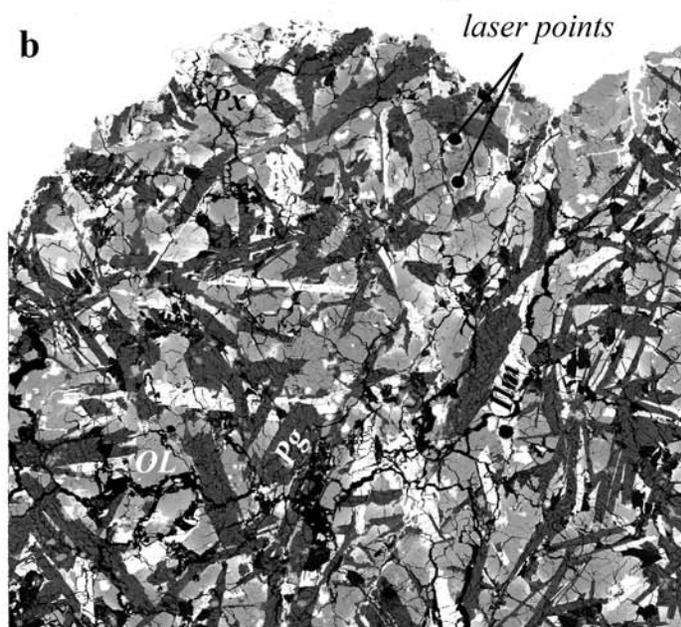
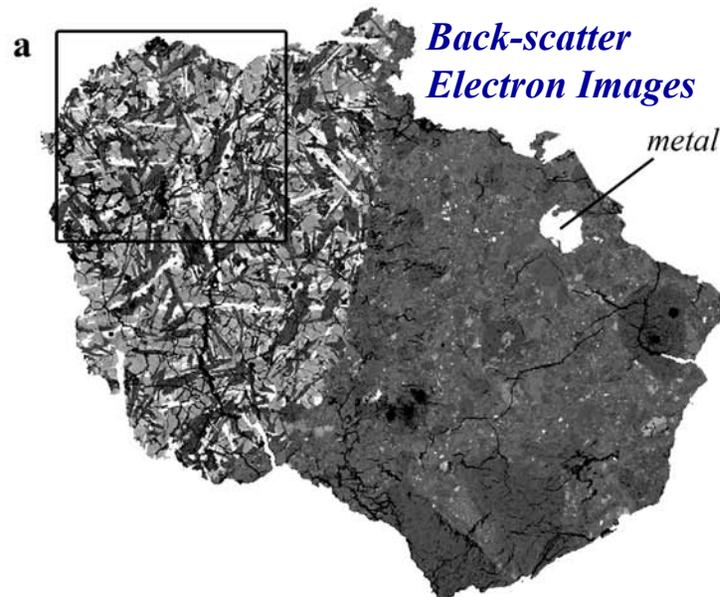
Color Key

R: Ca

G: Mg

B: Si

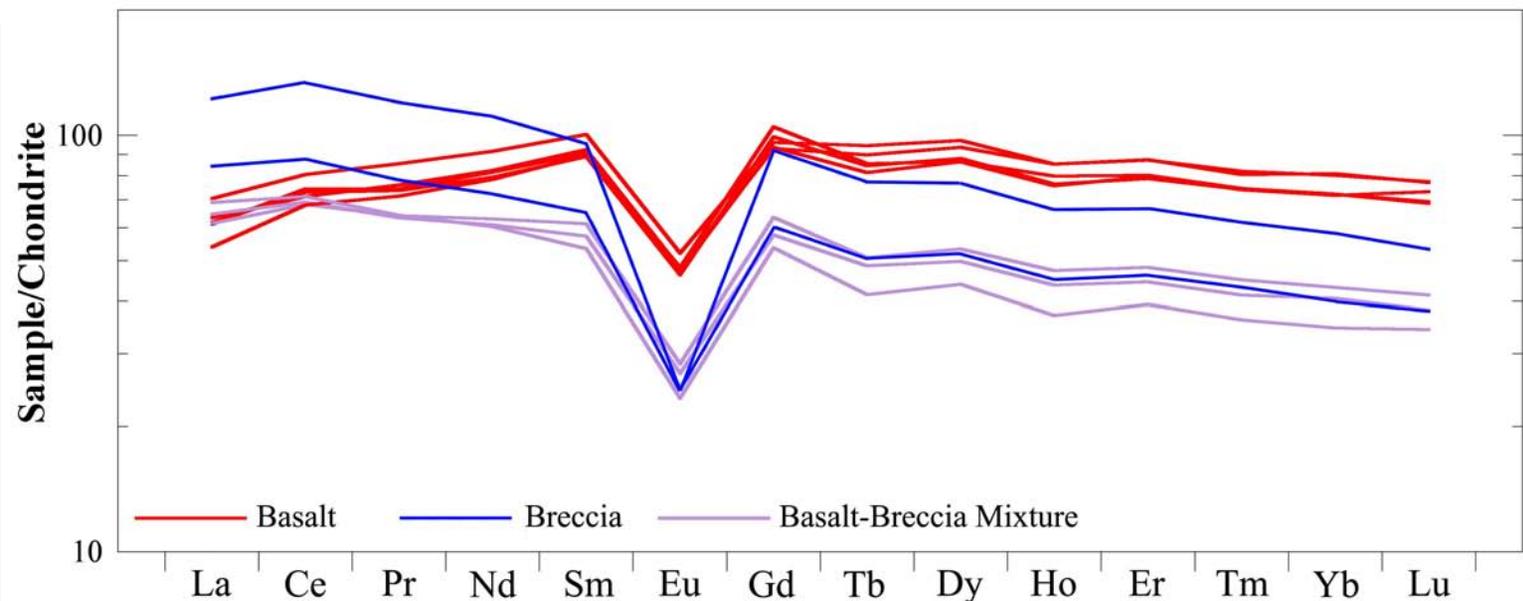
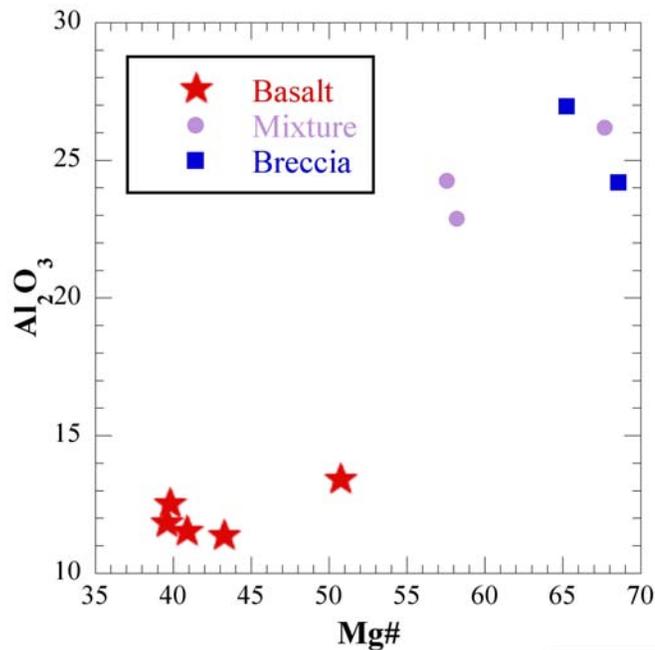
Delano (1975) 6th Proc.
Lunar Sci. Conf., 15-47.



Bulk Composition

Analytical Approach

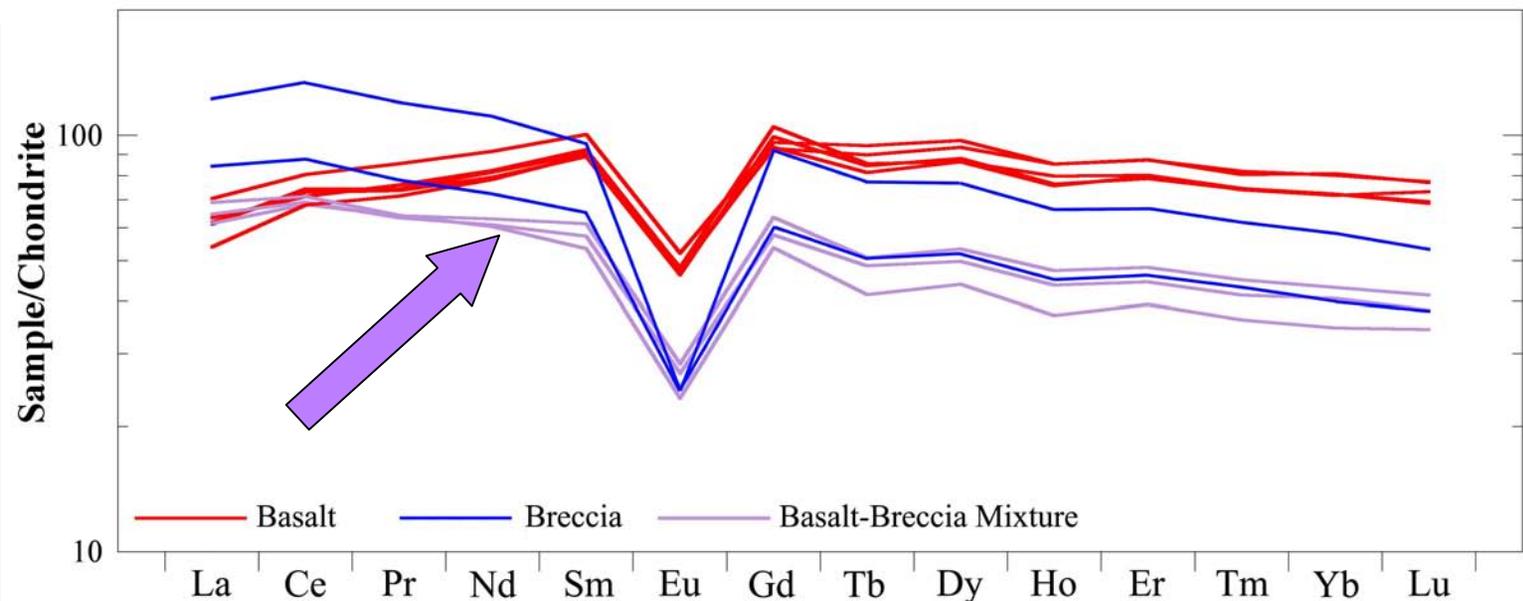
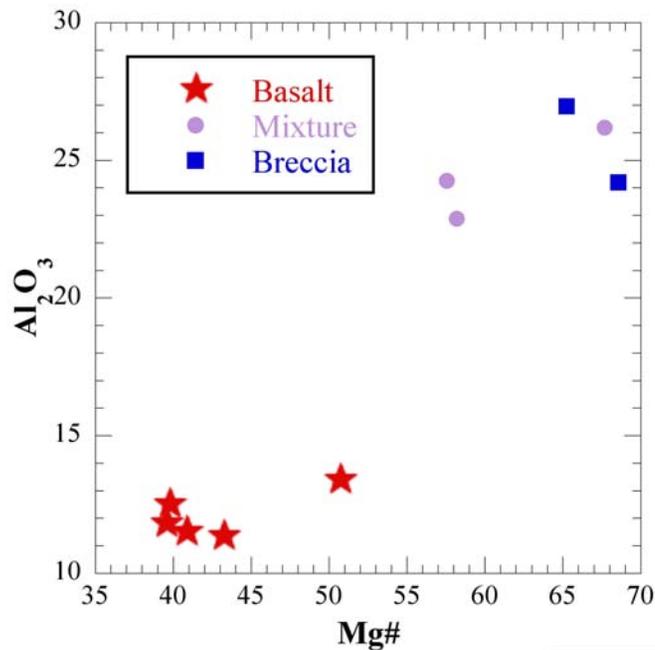
- digestion via HF & HNO₃
- Major elements by ICP-OES
- Trace elements by ICP-MS



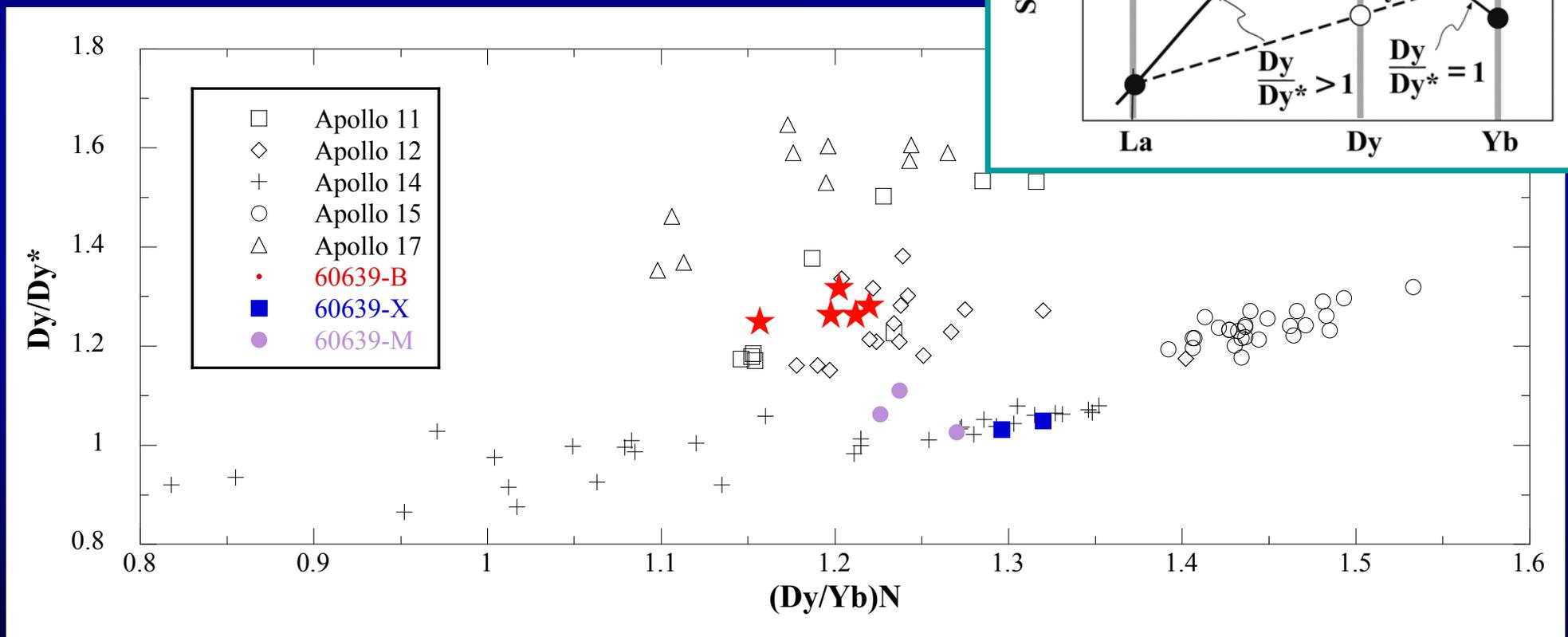
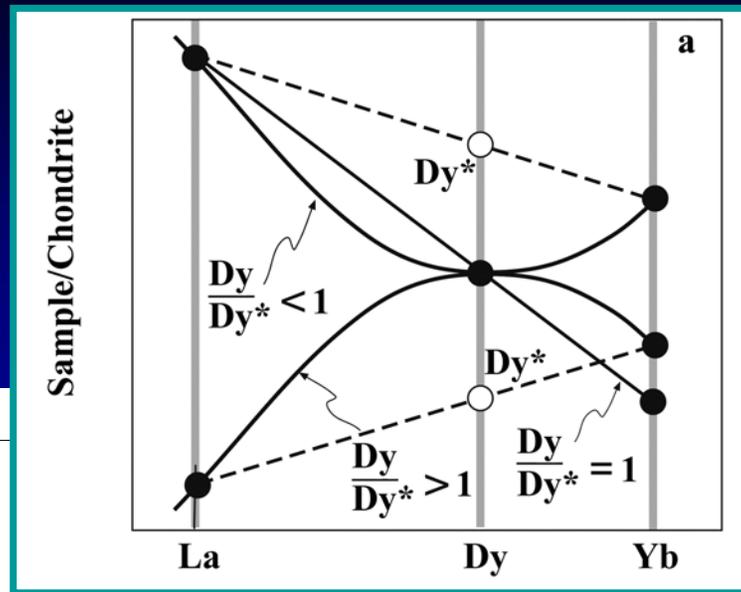
Bulk Composition

Analytical Approach

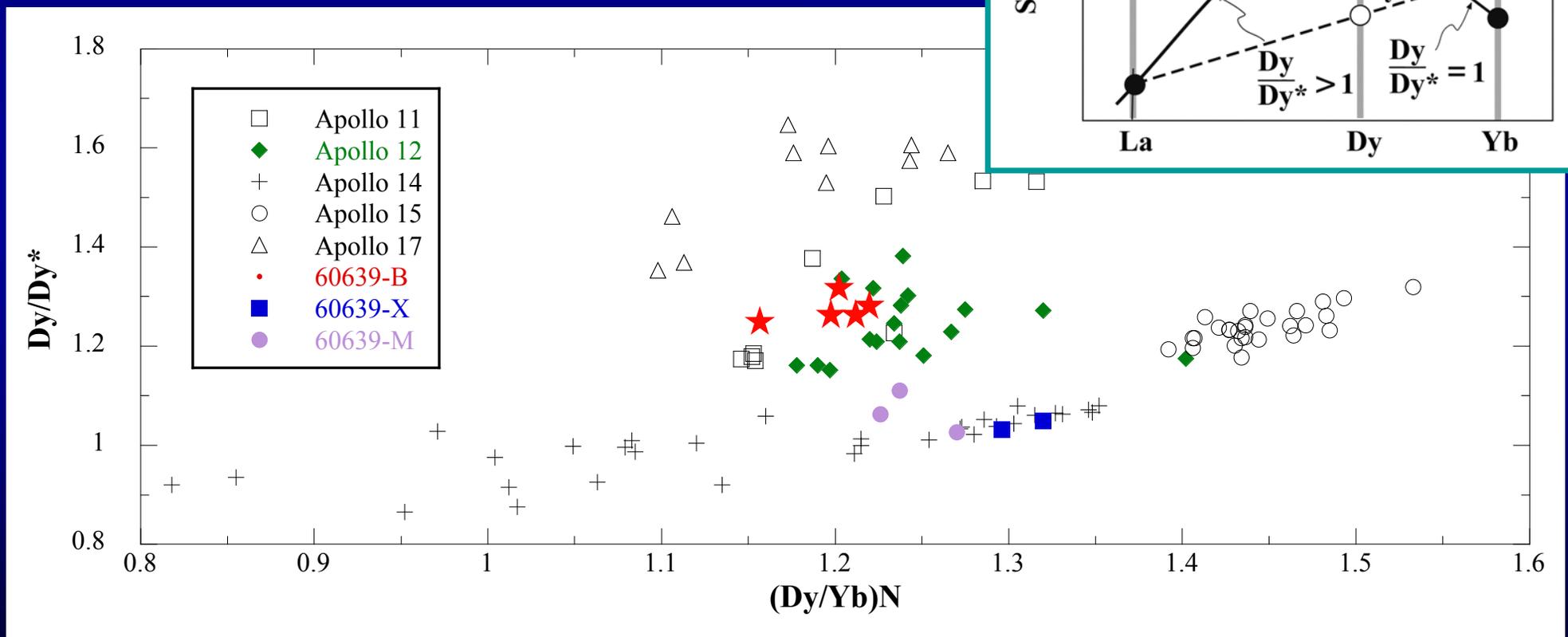
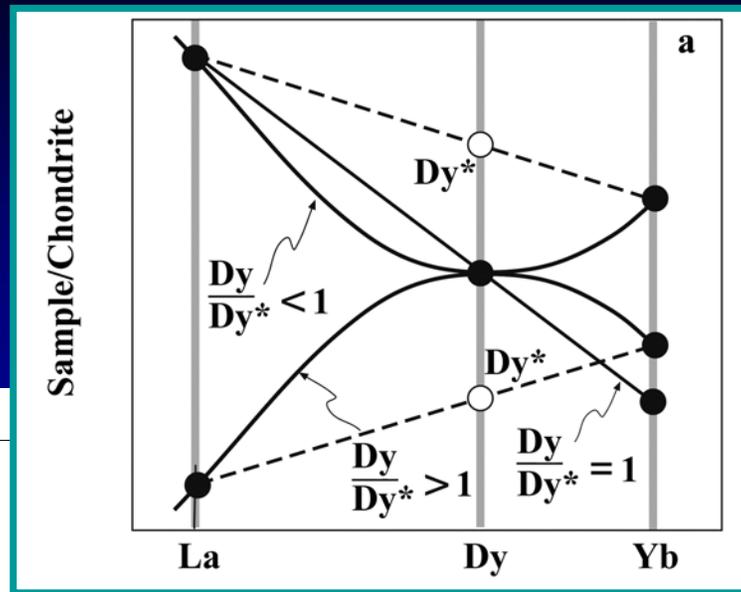
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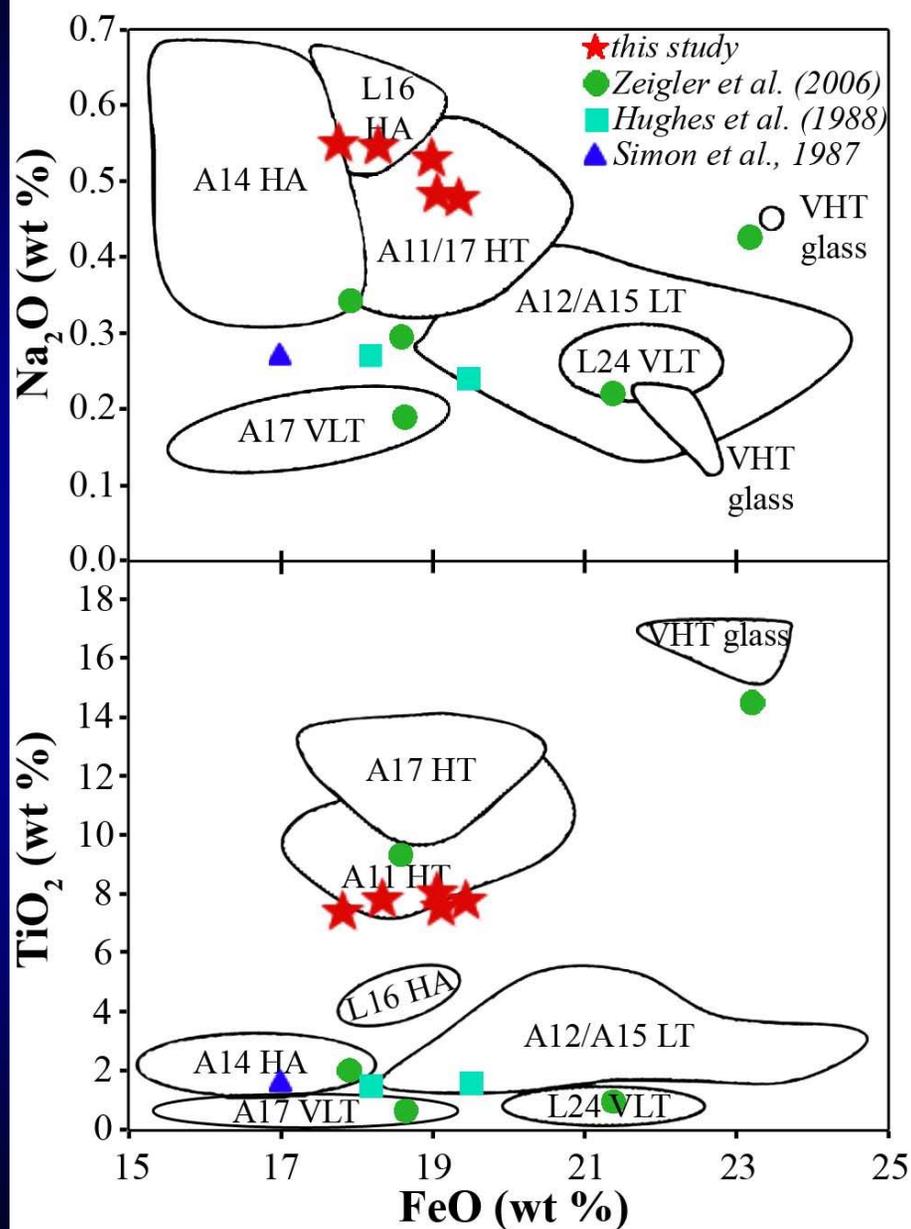


Link to Apollo 12

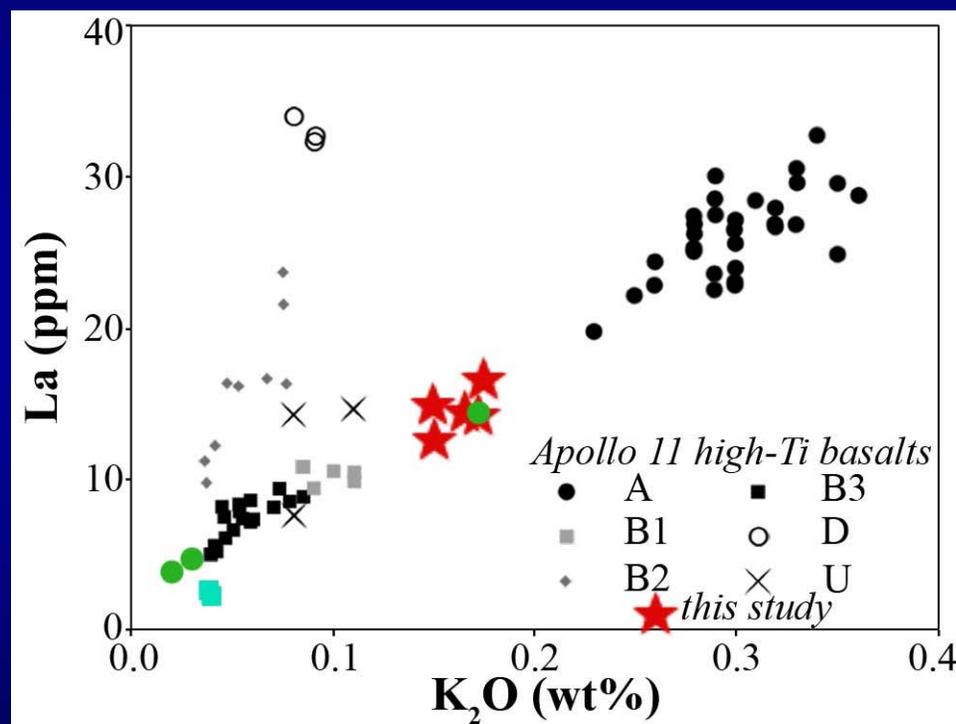


Link to Apollo 12





Link to Apollo 11



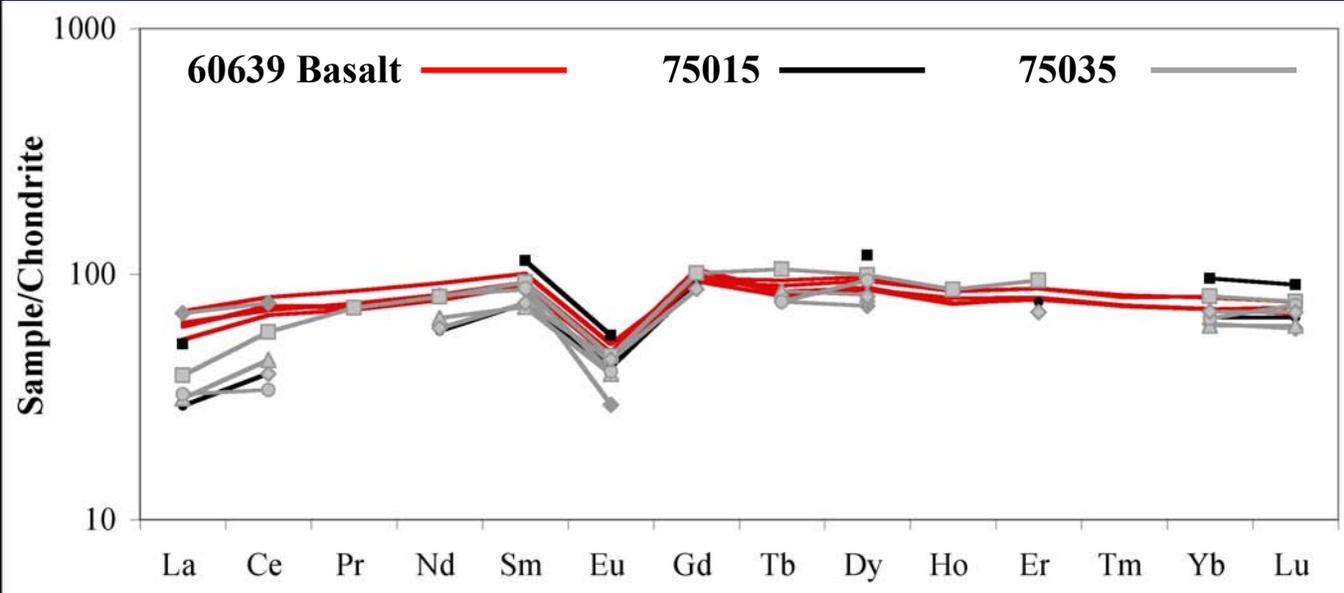
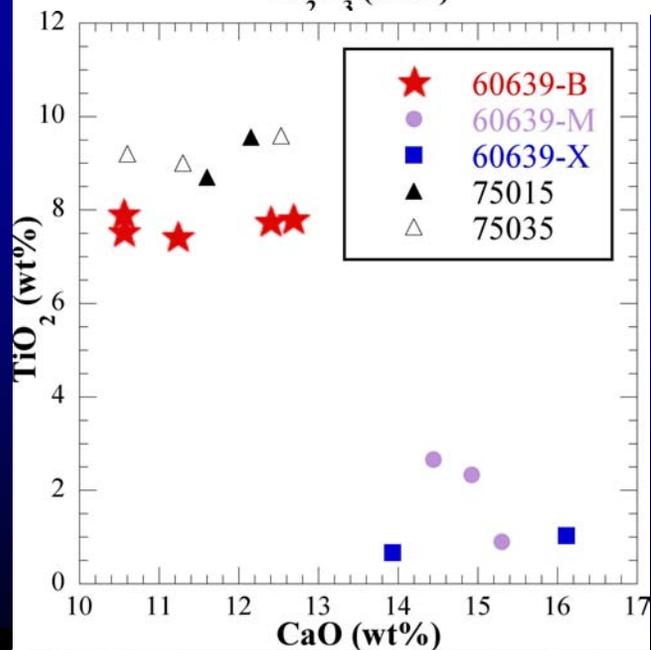
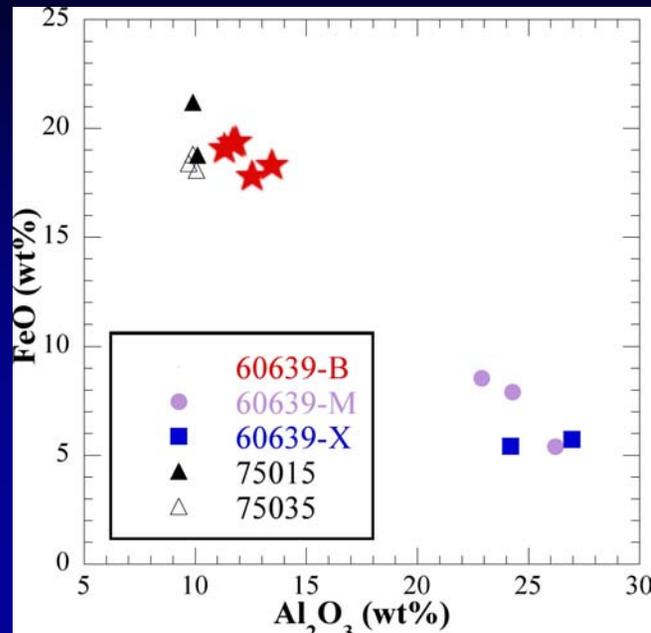
Hughes et al. (1988) *LPSC 19*, 515-516.

Jerde et al. (1994) *GCA* **58**, 515-527.

Simon et al. (1987) *LPSC 18*, 922-923.

Zeigler et al. (2006) *Met. & Planet. Sci.*, 41, 263-284.

Link to Apollo 17



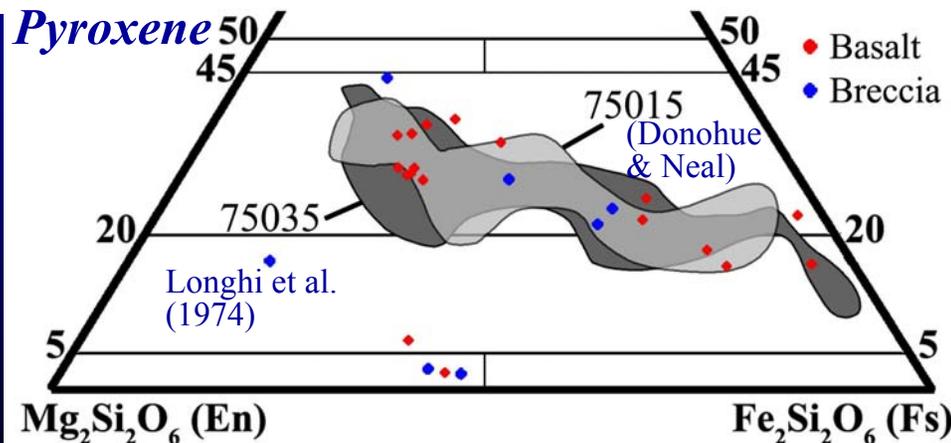
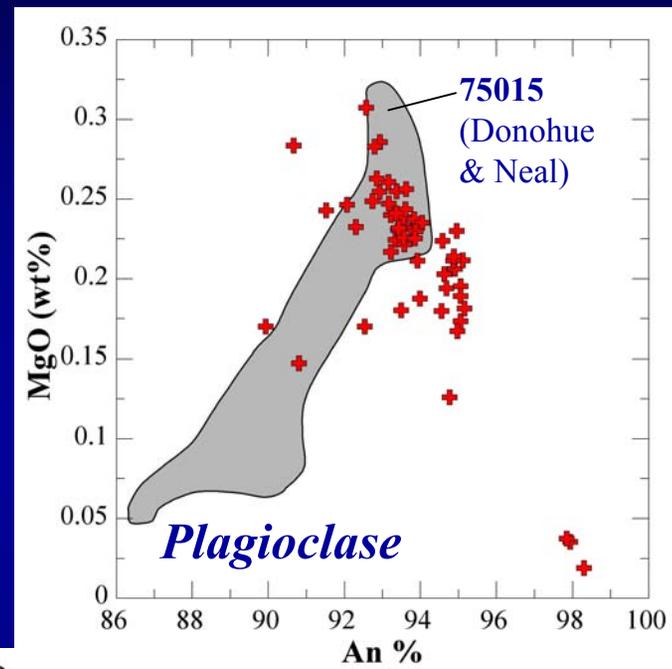
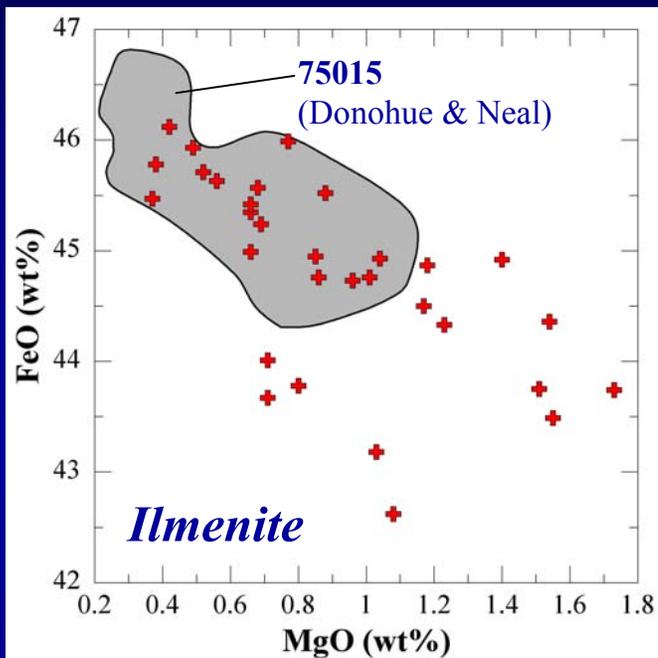
75015 Data:

Rhodes et al. (1976) *7th Proc. Lunar Sci. Conf.*, 1467-1489
 Warner et al. (1975) *Conf. on Origins of Mare Basalts & Imp. For Lunar Evolution*, 179-183.

75035 Data:

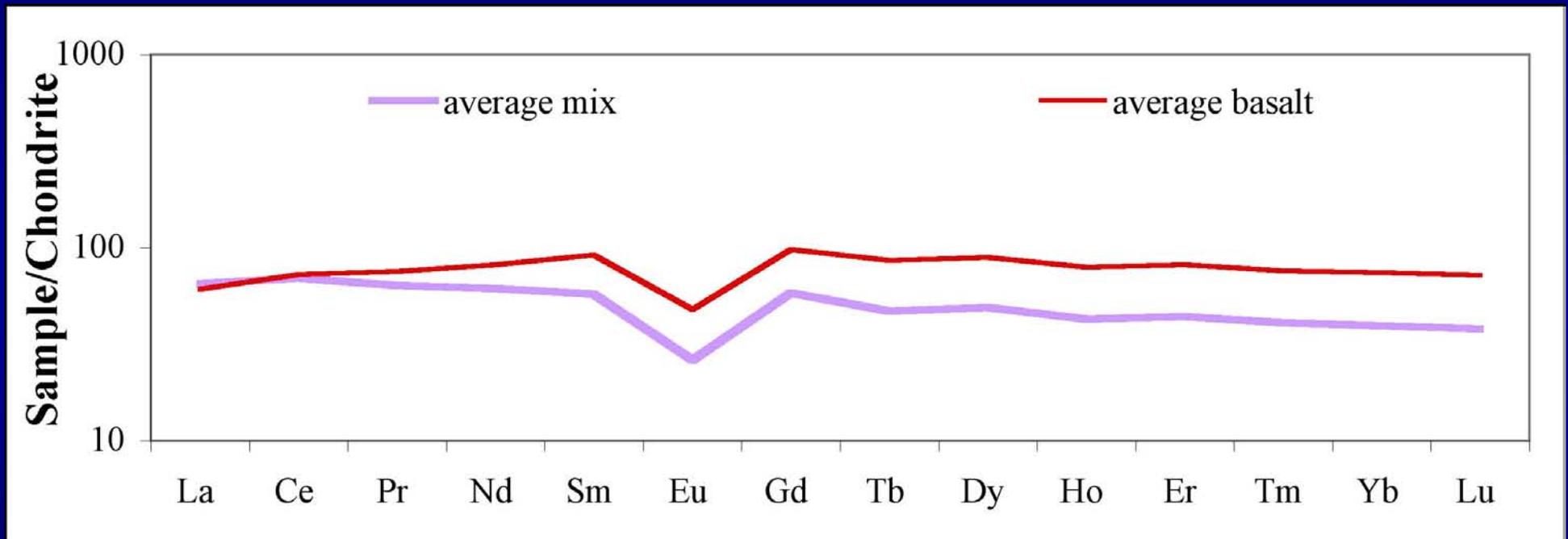
Brunfelt et al. (1974) *5th Proc. Lunar Sci. Conf.*, 981-990.
 Laul et al. (1974) *7th Proc. Lunar Sci. Conf.*, 501-511.
 Philpotts et al. (1984) *5th Proc. Lunar Sci. Conf.*, 1255-1267.
 Wänke et al. (1975) *6th Proc. Lunar Sci. Conf.*, 1313-1340.

Link to Apollo 17-Mineral Chemistry

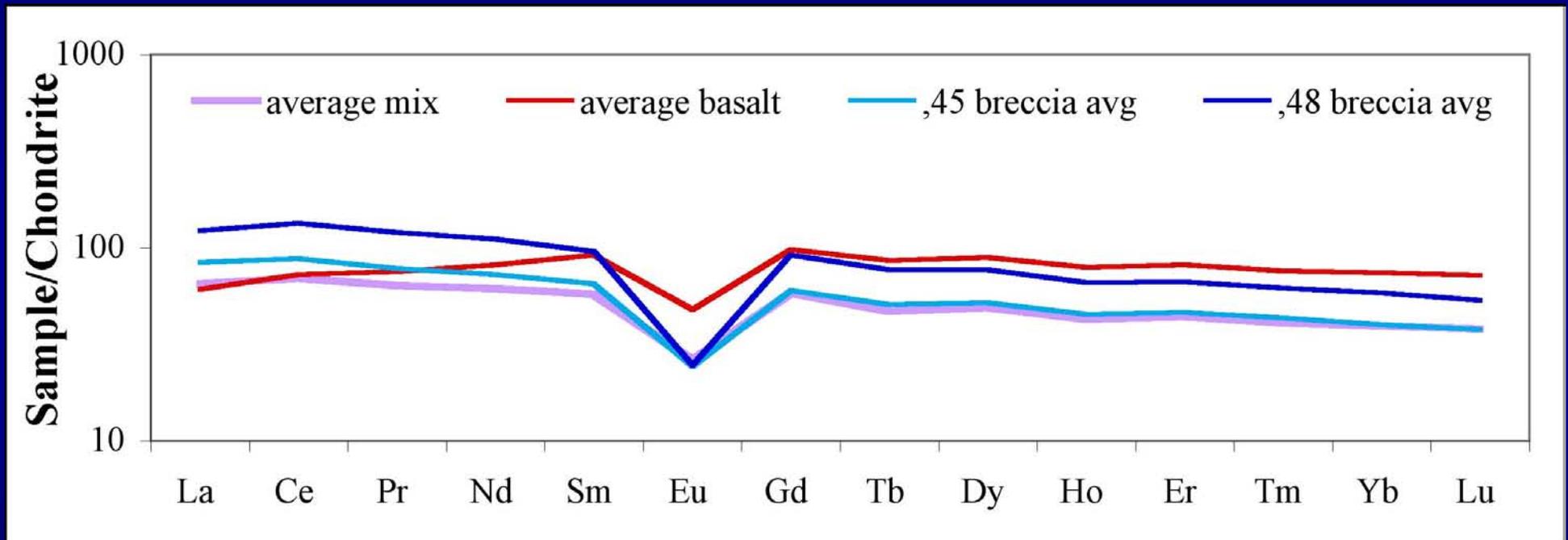


Donohue & Neal (in preparation)
Longhi et al. (1974) *5th Proc.
Lunar Sci. Conf.*, 447-469.

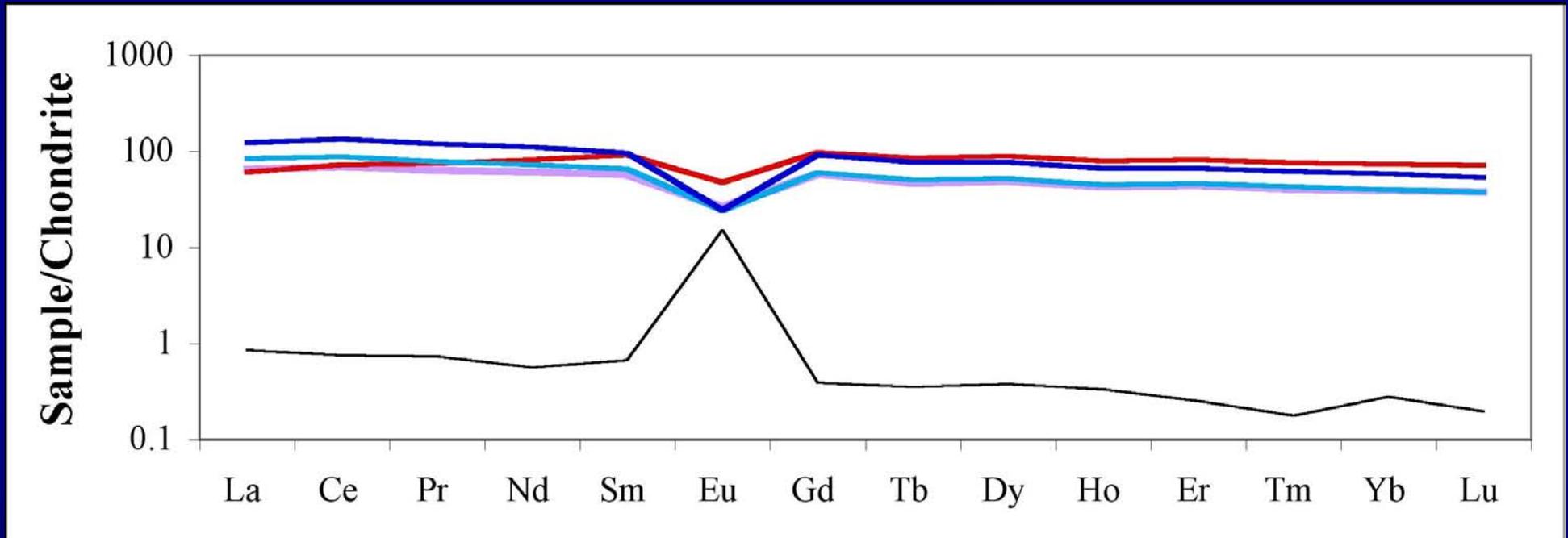
The Conundrum...



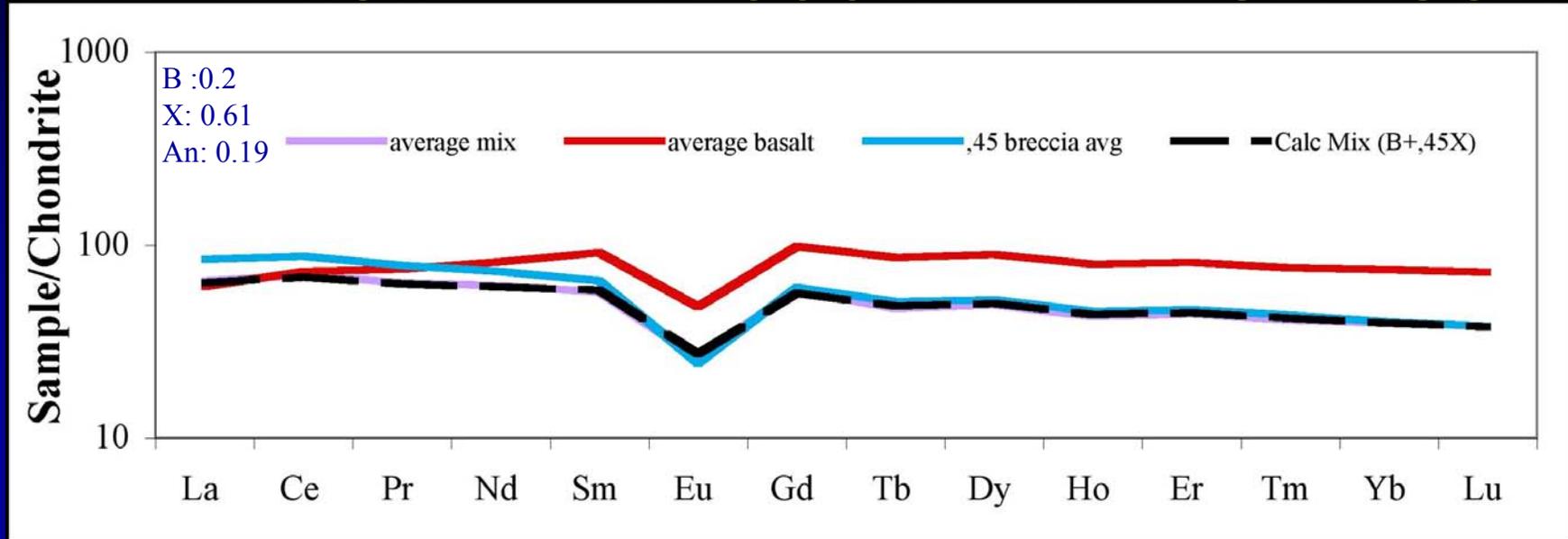
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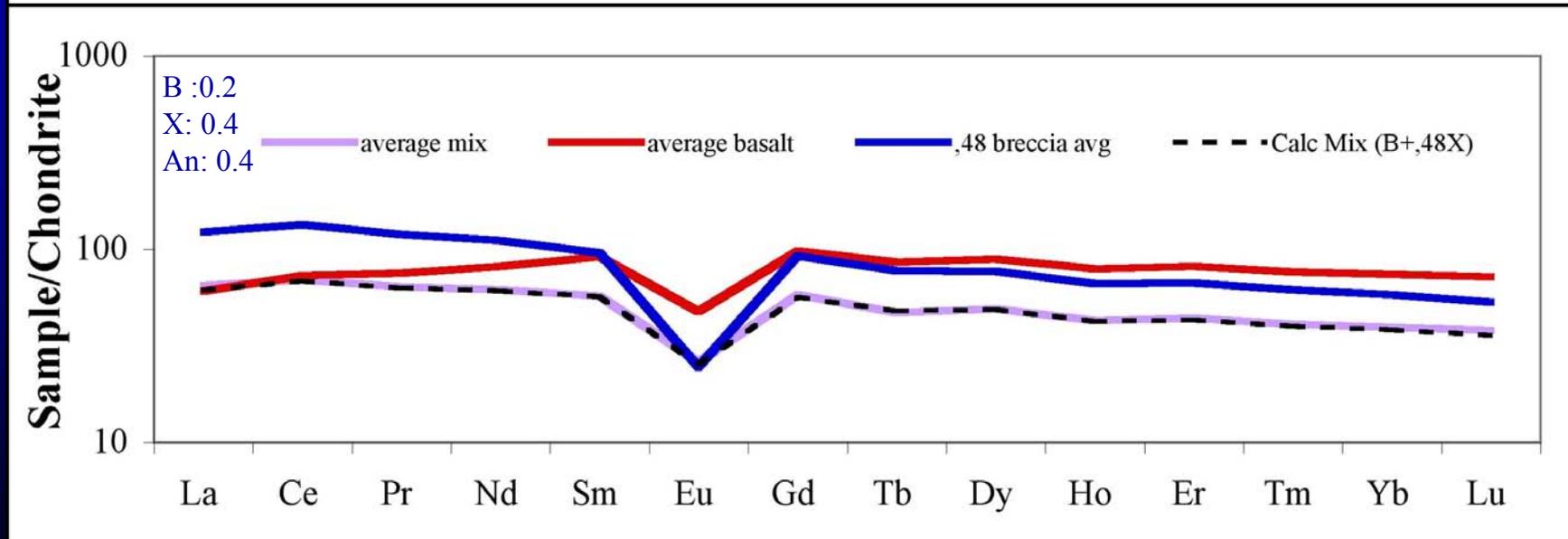
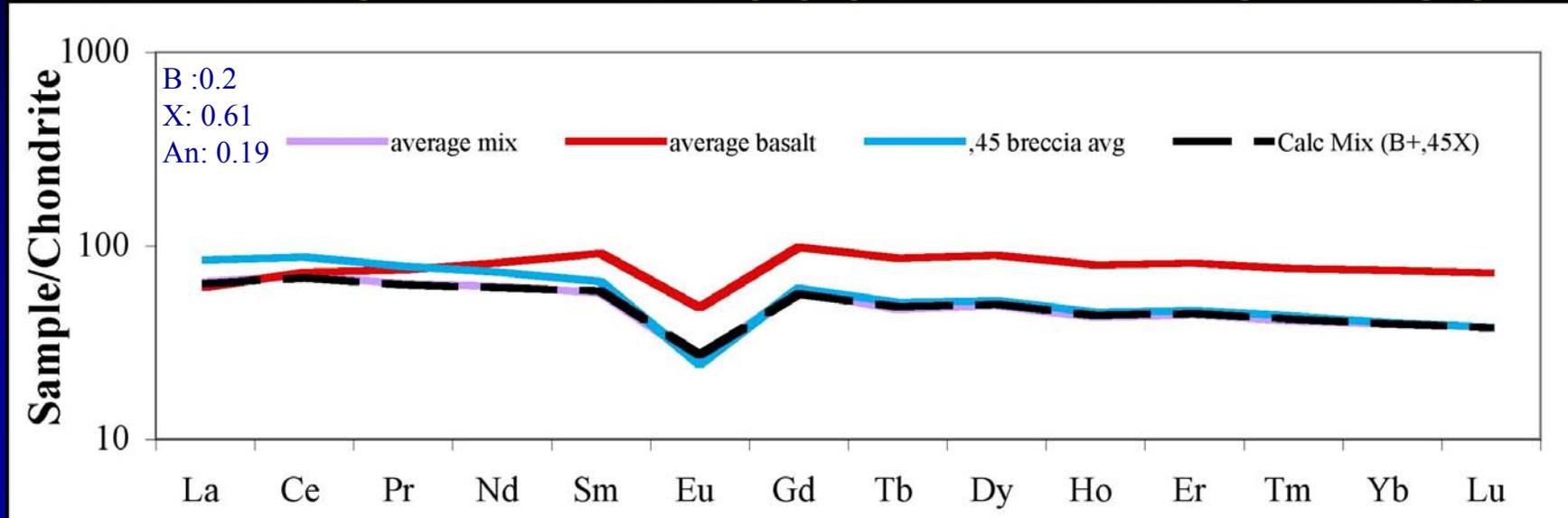
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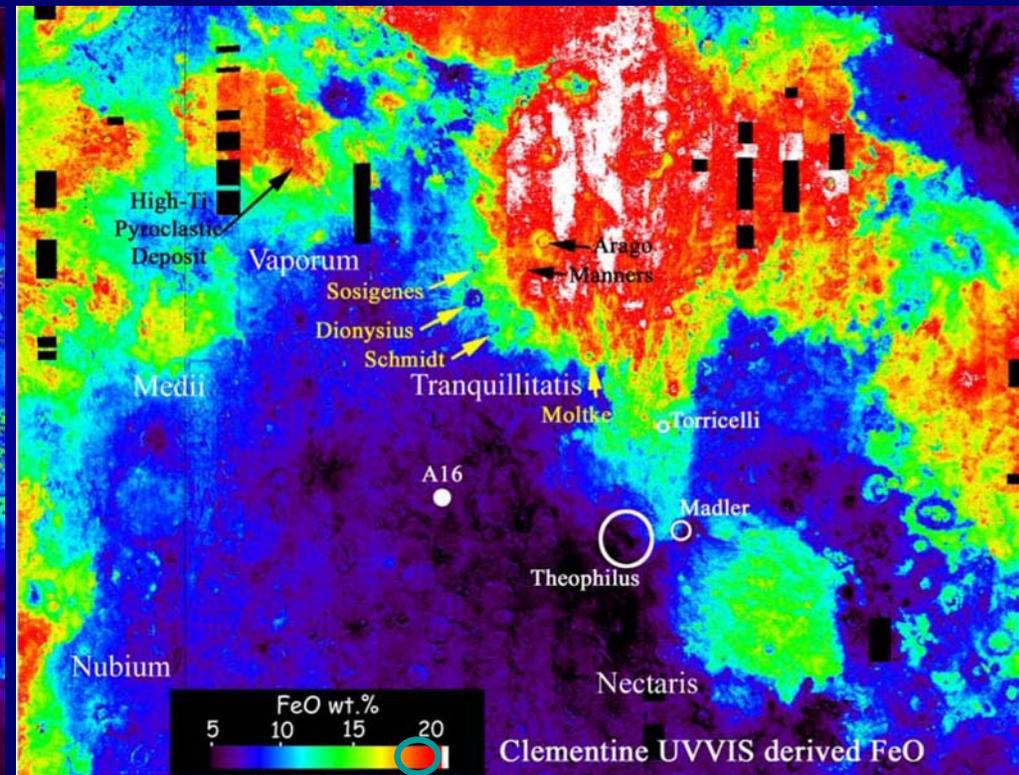
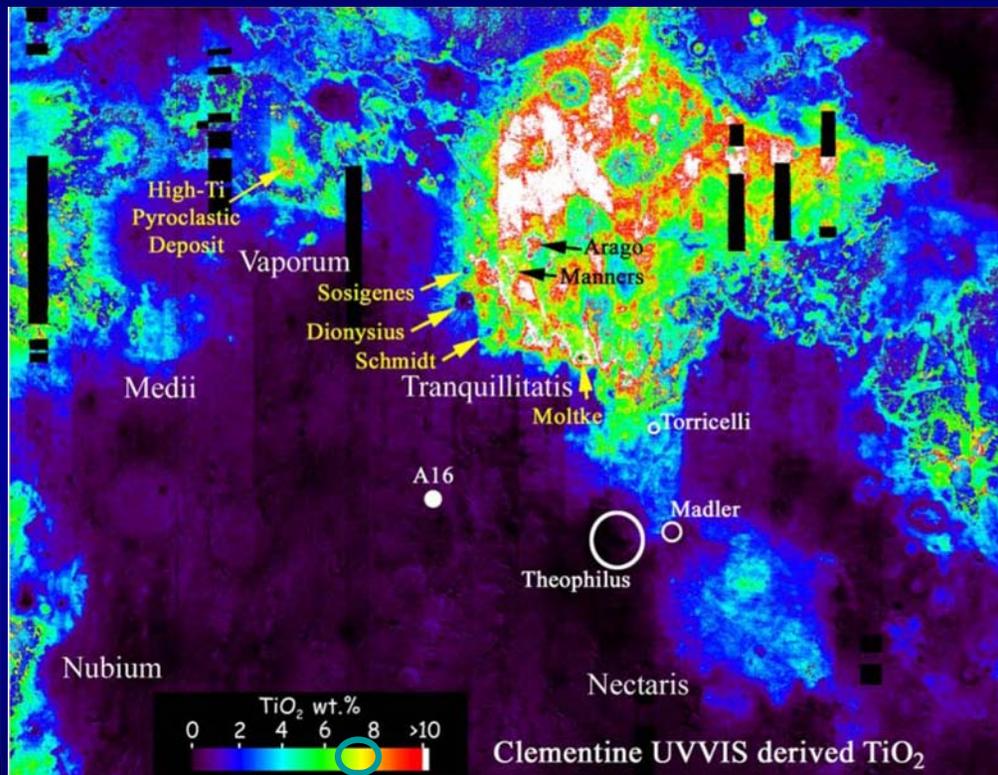
Mix = Basalt + Breccia + Anorthosite



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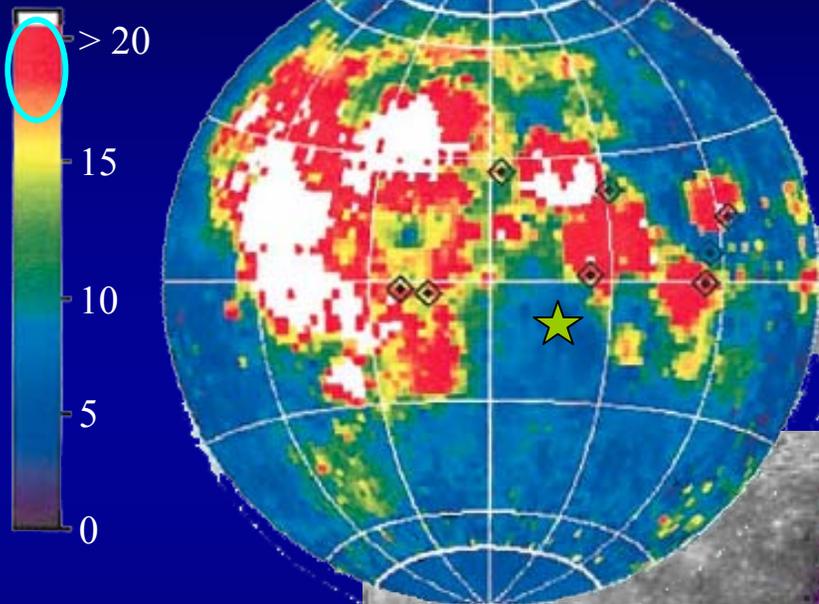
Potential Basalt Origins



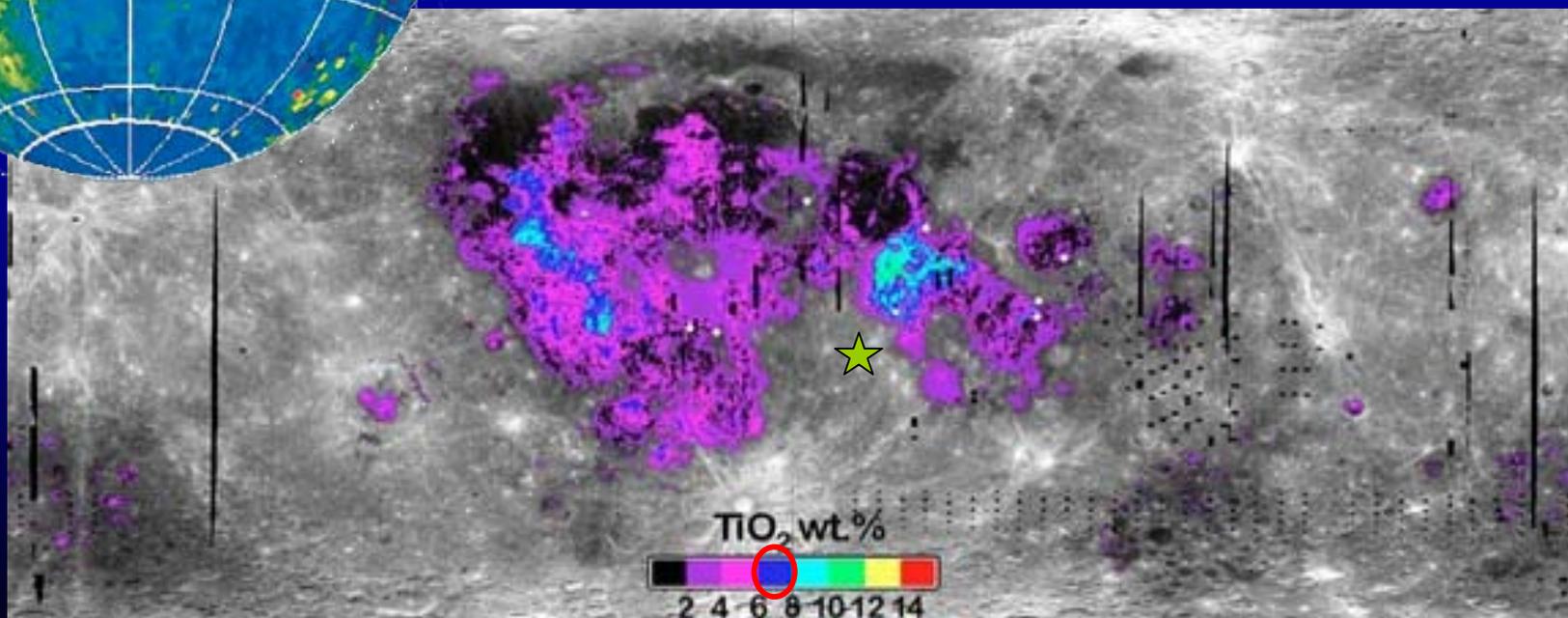
Zeigler et al. (2006) *Met. & Planet. Sci.*, 41, 263-284.

Potential Basalt Origins

FeO wt%



TiO₂ wt%

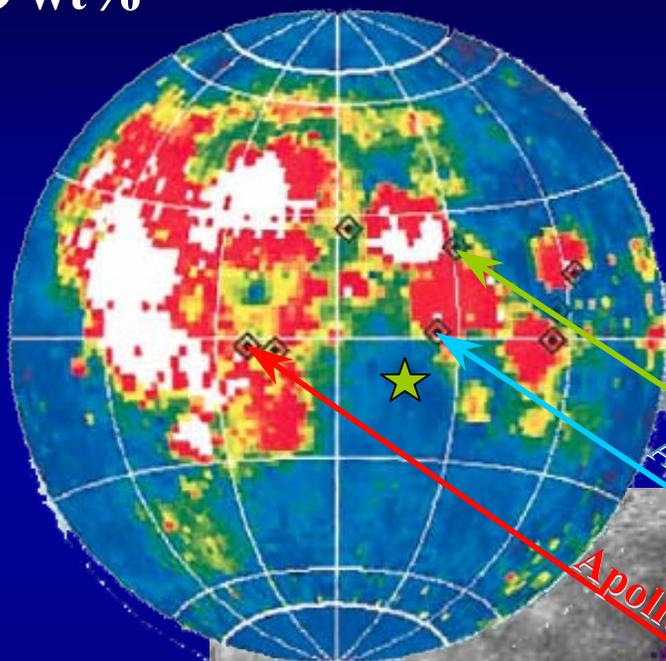
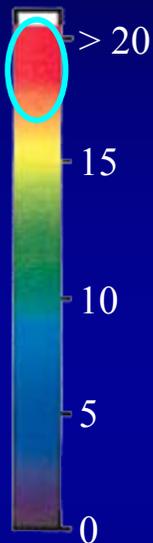


TOP: Gillis et al. (2003)
JGR, 3-1:3-18.

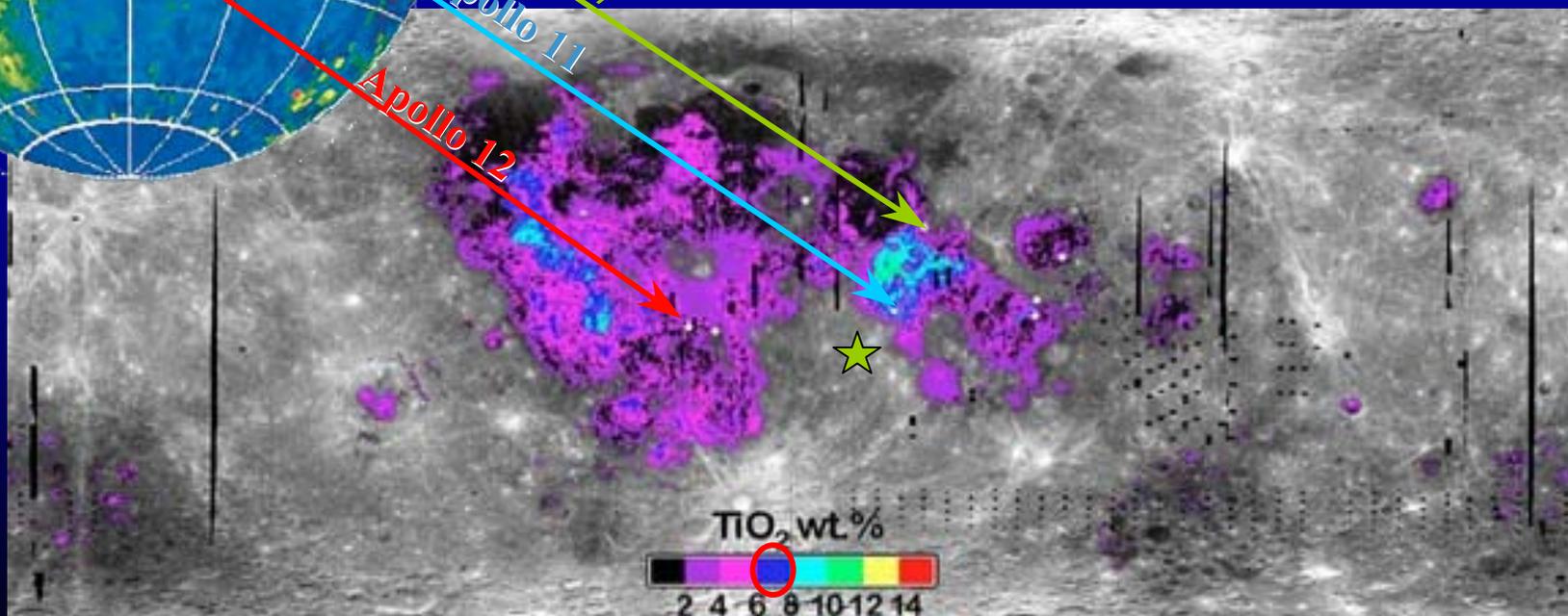
RIGHT: Gillis et al.
(2004) *GCA*, 3791-3805.

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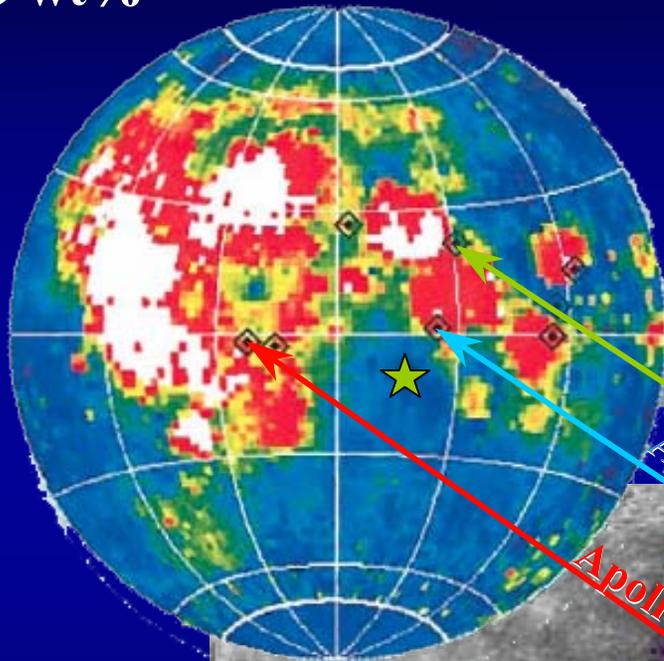
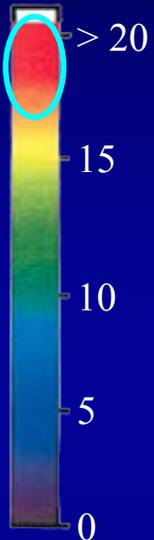


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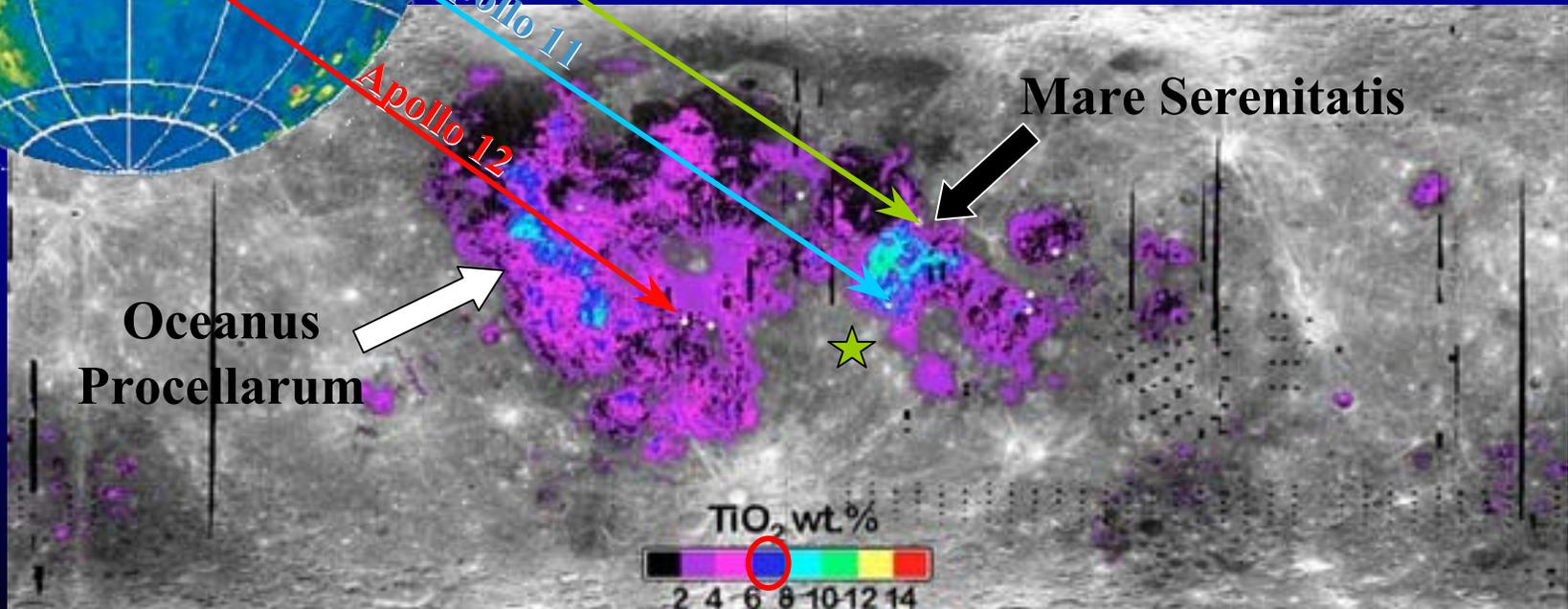
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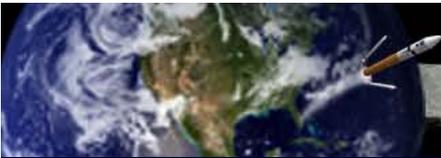
RIGHT: Gillis et al.
(2004) *GCA*, 3791-3805.

Summary

- Single Basalt flow
- Bulk composition similarities with basalts from other sites
 - Apollo 12: Dy/Dy*-dominance of clinopyroxene
 - Apollo 11/17: major elements
 - Apollo 17-75015 & 75035:
 - major and trace elements (bulk composition)
 - Major elements (mineral phases)
- Incorporation of Anorthosite with Breccia + Basalt
- Actual origin?
 - Need spectral data and ejecta modeling

This work was funded through the NASA Lunar Science Institute subcontract 02713-05. Many thanks to Paul Carpenter and Jon Loftus for their assistance with the EMP and ICP-OES, respectively.





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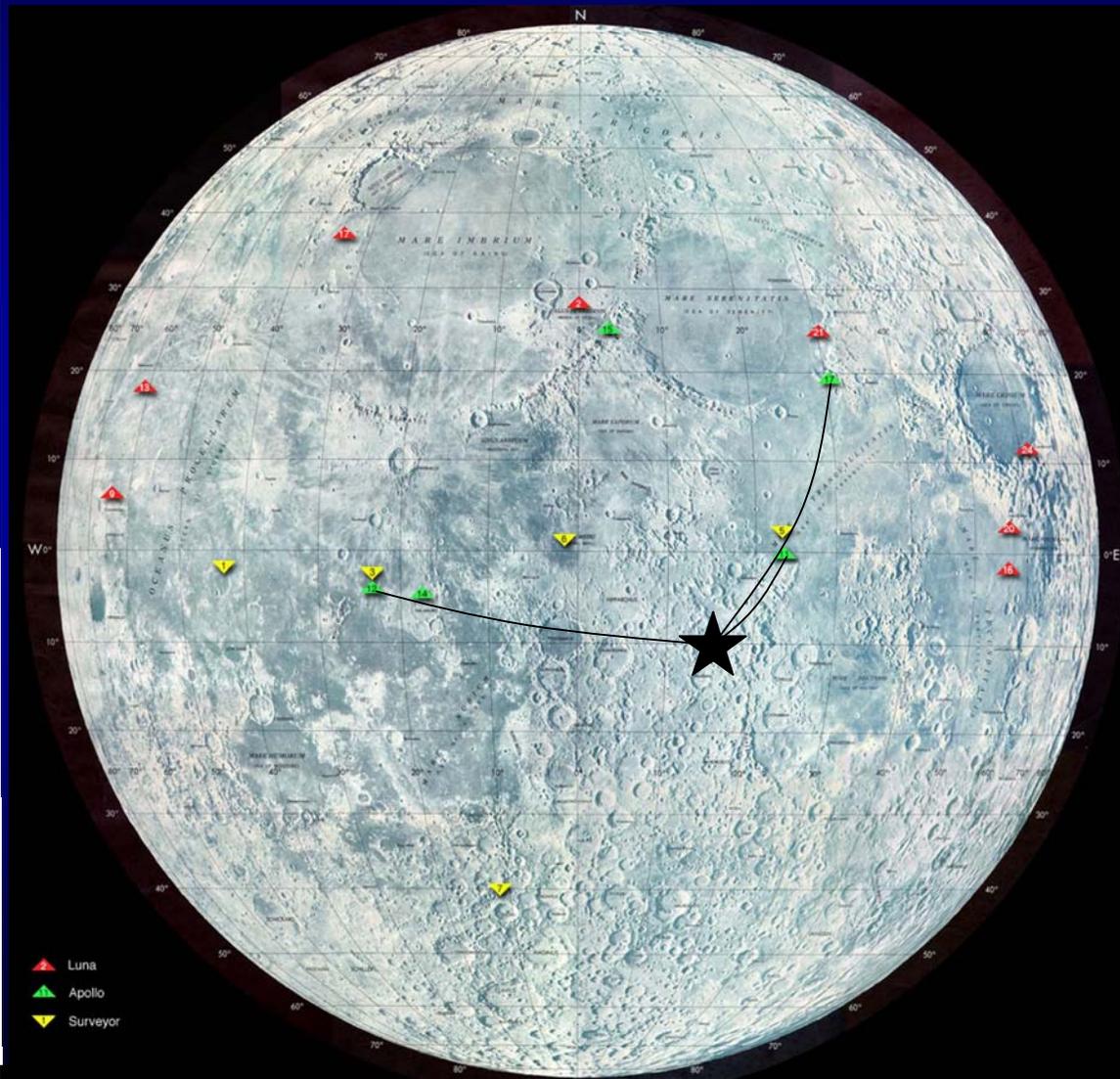
NASA Johnson Space Center
Astromaterials Research & Exploration Science



THE UNIVERSITY
OF ARIZONA



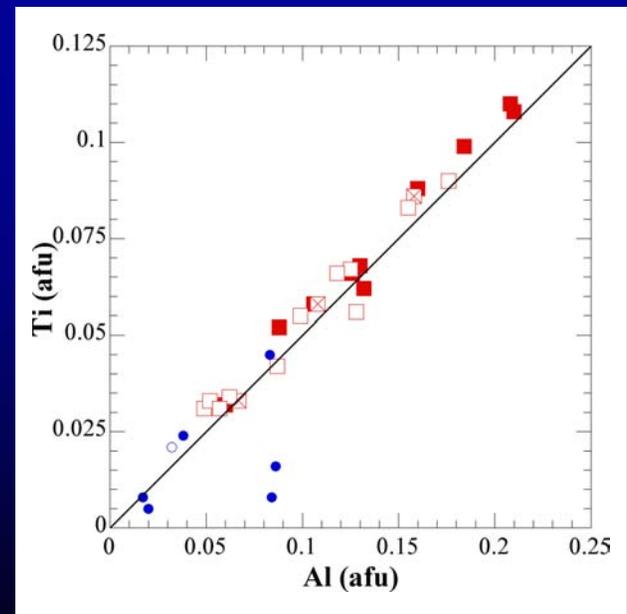
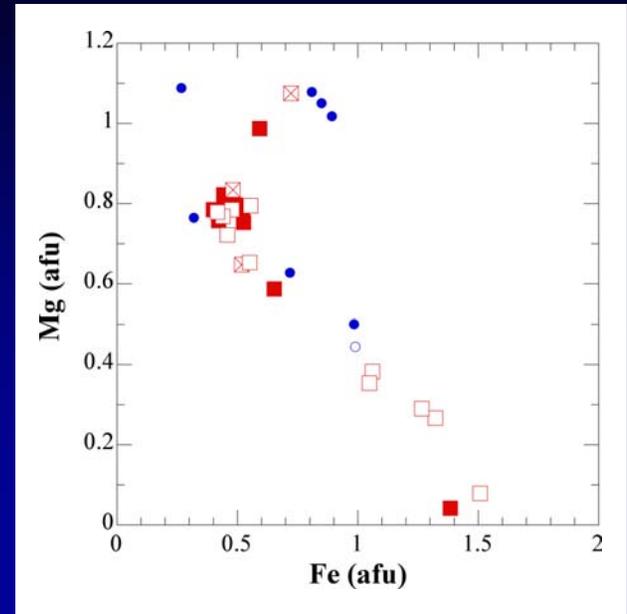
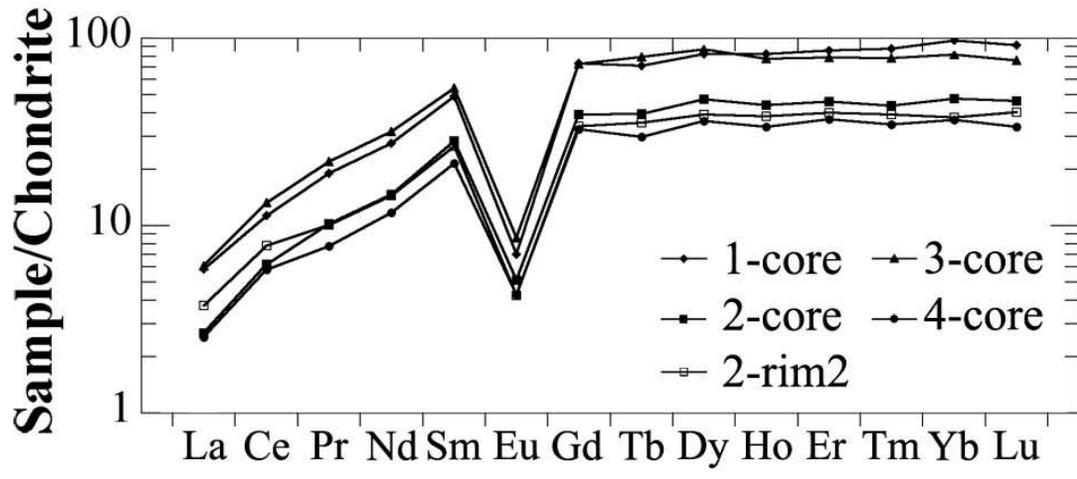
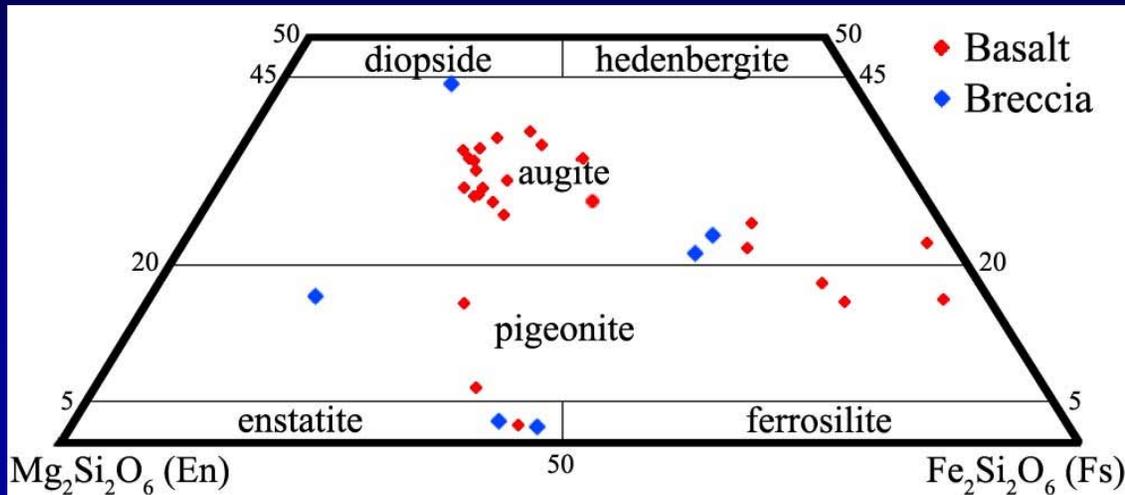
Distance to other Sites



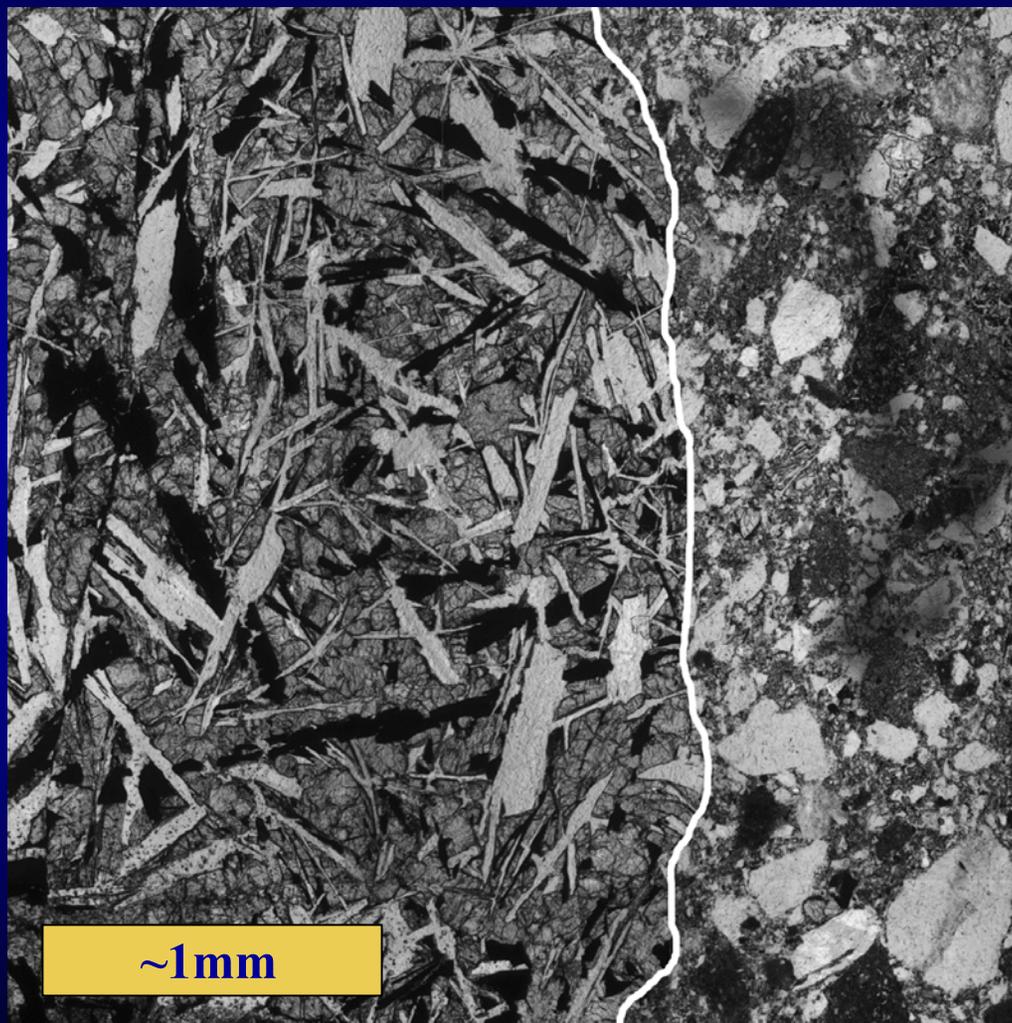
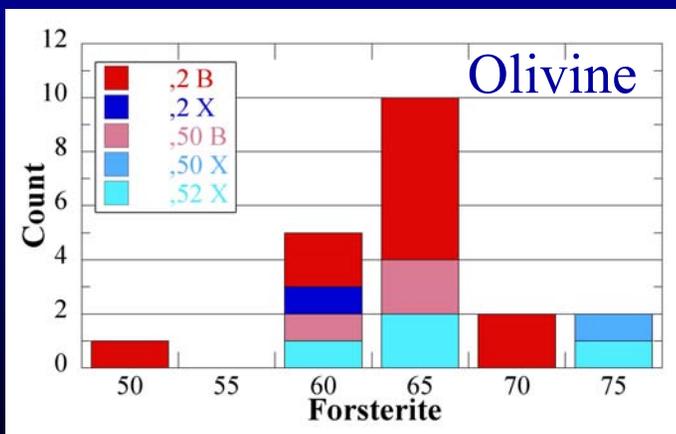
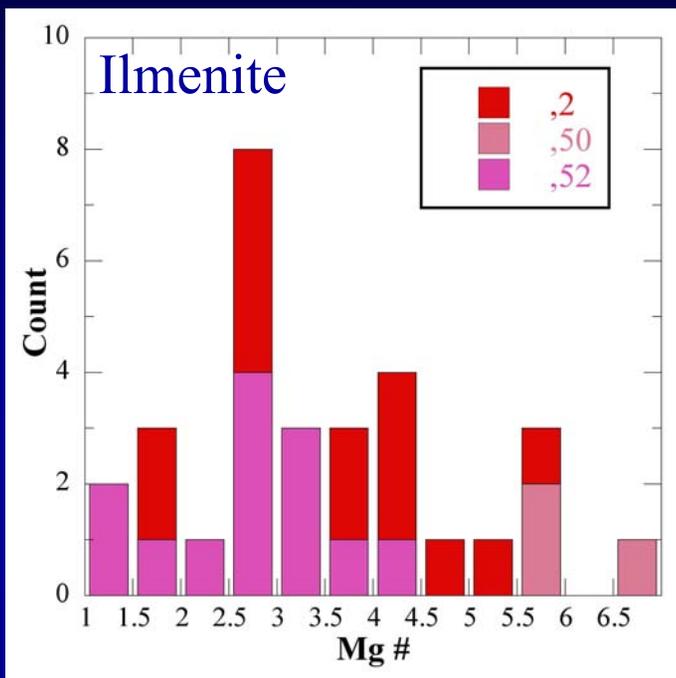
Distance between Apollo 16 Site and Possible Basalt Origins:

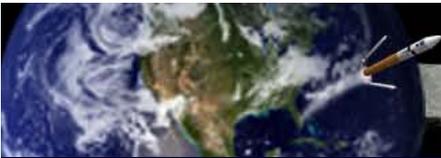
- 11: ~379 km (~235 mi)
- 12: ~1187 km (~737 mi)
- 17: ~995 km (~618 mi)

Pyroxene Chemistry



Ilmenite and Olivine





Plagioclase

